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NATIONAL
FRUIT AND CIDER INSTITUTE,
LONG ASHTON,
NEAR BRISTOL.

REPORT

FOR THE YEARS

1903-10.

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REPORT ON THE WORK OF THE NATIONAL FRUIT AND CIDER INSTITUTE, 1903-10.

BY B. T. P. BARKER, M.A., *Director,*

AND

JOHN ETTLE, F.R.H.S., *Superintendent of the Fruit Department.*

It has been considered desirable to issue a summary of the experimental and other work which has been accomplished, and the steps which have been taken to promote the interests of the fruit and cider industries by the Institute during the period dating from its establishment in the autumn of 1903 until the expiration of the original lease in September, 1910. The property originally leased was about 15 acres in extent—3 additional acres have since been taken—and included a few farm buildings, which were in due course suitably modified to serve for cider-making purposes and for market fruit storage. A small laboratory was also erected. The land taken over consisted of an old cider orchard about 5 acres in size and the remainder pasture. The old orchard is being replanted with young trees as the existing ones die or become valueless. A fresh cider orchard of similar size has been planted with a selection of the best vintage varieties. The rest of the land has been broken up, $1\frac{1}{2}$ acres being used as a nursery for the propagation of the most valuable vintage apples and pears, another $1\frac{1}{2}$ acre plot being utilised as a trial plantation for vintage apples grown in the bush form on the Paradise stock, and the remainder planted with the usual out-door market fruits.

The account of the work may be conveniently divided into two sections, the one dealing with the experimental work in connection with cider-making and fruit-culture, and the other with educational, advisory and other work.

THE EXPERIMENTAL WORK.

The account of this work is divided into two main sections, the one including all matter relating to the problems of cider-making, and the other being confined to questions concerned with the culture of market fruit. The division in this form is made so as to allow of the subject of cider-making being dealt with comprehensively : and it does not represent the actual division of the work between the cider-making and the fruit departments. Much of the work in the orchards and nurseries has at least as much significance from the cider-making point of view as from that of fruit culture.

Reference has been confined mainly to investigations which have already yielded more or less definite results. There are, however, several problems in connection with which experiments are in progress which have not been mentioned, since there has not yet been time for results of value to come to hand. This is especially the case in the work dealing with fruit culture, since several seasons' growth is required in many instances before the trees come into full bearing.

INVESTIGATIONS ON CIDER-MAKING.

At the outset it may be stated that the earliest results pointed very clearly to the view that the key to the position in the production of cider—which term may be taken here and in the following pages generally to include perry as well as cider—is the quality of the fresh juice as it leaves the press. Further experience has strengthened that view, and has justified the proposition that the character of a cider is determined primarily by the quality of the juice from which it is made ; and therefore, while it can be adversely affected by bad management, it cannot be improved beyond a certain point by the best possible treatment. The true perspective of the various phases of cider production can be seen by re-stating this proposition in the following form :—“ Up to the time of pressing the cider-maker is concerned with the production or development of quality, whereas after that point he can only deal with that already determined, and cannot do more than make the most of it.” Thus the various operations generally understood to constitute cider-making are comparatively of secondary importance, since they are concerned only with the utilisation of the available material to best advantage. At the same time it must not be thought that little attention to those details need be paid by the maker, since potential quality is of little value unless it is realised. It is, however, the period before the fruit is pressed which must be regarded as the crucial time in cider-making ; and consequently

attention to the fruit side of the problem is likely to have more far-reaching results, and to lead to more permanent improvement in the industry, than any devoted to the juice and its treatment. It is for this reason that the various problems connected with cider fruit figure so conspicuously in the following pages; and it is quite certain that this prominence is called for, since there is a very general tendency among cider-makers to limit their attention almost wholly to the juice and its treatment.

Vintage Varieties: Their Value and Classification.

Naturally the first points to require consideration are the kind of fruit utilised and the influence of individual varieties upon the character of the cider produced. So many sorts are used for cider-making that much of the work in this direction is still in its infancy, although a considerable amount of information has been gained about a large number of the more prominent varieties. When this work was first started, there was little general, well-authenticated knowledge of the value of even the best known sorts, with the exception of a few famous types, such as Kingston Black and Foxwhelp. The separation of the varieties into three classes, the "sharps", the "sweets", and the "bitter-sweets", was recognised, the division depending upon the degrees of sourness and astringency of the fruit. As the result of the examination of a large number of kinds it is possible to support this classification by a chemical standard, apples containing normally more than .45 per cent. of malic acid in the juice being placed in the "sharp" class, those with normally less than .45 per cent. of malic acid and .2 per cent. of tannin in the "sweet" class, and those with normally less than .45 per cent. of malic acid but more than .2 per cent. of tannin in the "bitter-sweet" class. The limits proposed have been found to answer very well for general purposes; although, as with all classifications by arbitrary limits, there are certain border-line varieties about which there is some doubt as to the proper class in which they should be included.

The members of these classes differ considerably among themselves in several respects, of which the most obvious is the degree of richness in sugar. Within the limits of a single season the specific gravity of the juice may range from about 1.040 to 1.090, which is equivalent to an approximate range of from $7\frac{1}{2}$ to 20 per cent. of sugar. In the "sharp" class the percentage of malic acid found in juices of different varieties may reach as high as 1.5 per cent.; but there are not many sorts of recognised value for cider-making with acidities higher

than 1 per cent., and most of the esteemed sorts rarely exceed .75 per cent. The tannin contents in this class vary widely, some reaching from .75 to 1 per cent., with others as low as .03 or .04. In the "bitter-sweet" class the acidity in a normal season generally ranges between .15 and .3 per cent., while the tannin may exceed .7 per cent. in rare instances. Generally it lies between .2 and .7 per cent. In the "sweet" class the acidity is generally within about the same limits as in the "bitter-sweet" group, and the tannin between .1 and .2 per cent. The rate of fermentation of the juices in all classes shows wide variations. In some cases the daily fall in specific gravity at 27-28°C. is not more than .001-.002, while in other instances it may reach .015-.020. The differences in rate of fermentation have been proved to be due to the nitrogenous constituents of the juice which are assimilable by the yeasts. The greater the quantity of these substances the more rapid is the rate of fermentation. Other features of vintage importance, such as the amount and nature of the mucilaginous constituents and the yield of juice, show similar wide variations; but the numerical records are not sufficiently extensive or reliable to allow of any general statement. It is clear, however, that by chemical analysis alone very great differences in the vintage quality of individual varieties are demonstrated. During the past seven years over 2,000 different juices have been analysed, so that these general results may be taken as thoroughly representative of the quality of the vintage fruit of this country.

Single Variety Ciders.—It was recognised, however, at the start of the work that, while the chemical analysis of the juice furnished valuable and indispensable information, it was insufficient by itself to enable any satisfactory decision as to the vintage quality of a variety to be arrived at, except in so far as indicating that certain varieties on account of some extreme character in the composition of their juice were worthless for further consideration. Neither the "body" of the cider nor the characteristic flavour of the variety are revealed by the chemical analysis. Consequently it was decided that the only satisfactory plan to arrive at a decision as to the vintage value of a variety was actually to make cider from the variety alone: and such single-variety ciders have been from the beginning the characteristic feature of the cider work at the Institute.

Over 250 of these single-variety ciders have been made on a practical scale in the cider house; and a much larger number have been prepared on a small scale in the laboratory. The information afforded has not only been valuable on account of the knowledge derived as to the merits of individual varieties, but also on account

of the light thrown upon many general questions, such as the special qualities of importance for vintage purposes, the methods of management of juices of different types, and the variations in quality due to specific causes. Each of these will be referred to in due course.

In estimating the relative merits of individual varieties due regard must, of course, be paid to the type of apple under consideration. For example, a variety belonging to the sharp class cannot properly be compared with others belonging to the "sweet" or "bitter-sweet" classes, and can only be judged by standards afforded by other "sharp" apples; and the same rule holds good also for members of the other two classes. Thus the value of Kingston Black as compared with Strawberry Norman or Sweet Alford, cannot fairly be reckoned; but it can be placed in comparison with varieties of similar composition, such as Cowarne Red and Skyrme's Kernel.

The investigation of separate varieties in this manner has established the fact that as a rule better results can be obtained by blending than by the use of varieties separately. This point will be readily understood when it is considered that the limits of composition within which nearly all ciders which are well-balanced in flavour fall, are .35-.7 per cent. of malic acid, and .1-.3 per cent. of tannin. If these figures are compared with those referred to above in connection with the variations in composition of different varieties, it will be found that most varieties fall without those limits. It is a comparatively simple matter to bring the juice of the mixture within the limits stated by blending in suitable proportions members of the three classes of fruit. In spite, however, of these facts it is remarkable how large a number of the single-variety ciders can, with care in the management of the fermentation, be made palatable to drink unblended. This can be accomplished by regulating the amount of the sugar retained in the cider by checking fermentation at a suitable point. As a general rule, the higher the amount of malic acid or tannin in the cider the more sugar is required to mask or counteract the flavour of those constituents. In some instances it is found also that, although the composition of such ciders does not fall within the limits just stated, it is preferable not to blend, since they possess certain desirable features of flavour which are overwhelmed or negated by blending.

Stated generally, the characteristics of the ciders produced from the three classes of fruit—except in the relatively few cases of varieties which fall within the desired limits of composition—are as follows: sharp varieties yield ciders generally deficient in body and colour, and too brisk; sweet varieties, ciders generally well coloured and frequently of good body, but more or less insipid;

and bitter-sweet varieties, ciders usually of good colour and body, but lacking briskness and generally more or less too astringent.

Classification.—Sufficient information as to the characters of individual varieties has now been collected to enable a more complete and useful classification of vintage fruit to be formulated, so as to assist makers to utilise their fruit in the most advantageous manner. The outlines only of the scheme are here given, since too much space would be required to describe it in detail. The three classes of fruit previously referred to serve as the basis of the classification; and they are divided into sub-classes according to the degree of acidity or astringency respectively, these being subdivided again according to the normal rates of fermentation of the juices. The kind of blending recommended for the members of each sub-division is also included in the detailed scheme. The system of classification is as follows:—

CLASS A.—Sharp varieties (juices containing normally more than .45 per cent. of malic acid).

Sub-Class I.—Varieties with juices containing normally between .45 and .75 per cent. of malic acid.

Group 1.—Varieties with normally slow-fermenting juices. Type—Kingston Black.

Group 2.—Varieties with normally quick-fermenting juices. Type—Fair Maid of Devon.

Sub-Class II.—Varieties with juices containing normally between .75 and 1 per cent. of malic acid.

Group 3.—As Group 1. Type—Cap of Liberty.

Group 4.—As Group 2. Type—Underleaf.

Sub-Class III.—Varieties with juices containing normally above 1 per cent. of malic acid.

Group 5.—As Group 1. Type—Red Butcher.

Group 6.—As Group 2. Type—Gutter.

CLASS B.—Sweet varieties (juices containing normally less than .45 per cent. of malic acid and .2 per cent. of tannin).

Sub-Class IV.—Varieties with juices containing normally between .3 and .45 per cent. of malic acid.

Group 7.—As Group 1. Type—Northwood.

Group 8.—As Group 2. Type—Bran Rose.

Sub-Class V.—Varieties with juices containing normally less than .3 per cent. of malic acid.

Group 9.—As Group 1. Type—Sweet Alford.

Group 10.—As Group 2. Type—Morgan Sweet.

CLASS C.—Bitter-sweet varieties (juices containing normally less than .45 per cent. of malic acid and more than .2 per cent. of tannin).

Sub-Class VI.—Varieties with juices containing normally between .2 and .35 per cent. of tannin.

Group 11.—As Group 1. Type—Horner.

Group 12.—As Group 2. Type—Truckle.

Sub-Class VII.—Varieties with juices containing normally between .35 and .5 per cent. of tannin.

Group 13.—As Group 1. Type—Strawberry Norman.

Group 14.—As Group 2. Type—Spreading Norman.

Sub-Class VIII.—Varieties with juices containing normally more than .5 per cent. of tannin.

Group 15.—As Group 1. Type—Medaille d'Or.

Group 16.—As Group 2. Type—Tanners.

Standard Varieties.—The single-variety ciders have also afforded important information as to the relative value of the characters of the fruit which are useful for vintage purposes. These results were summarised in the Annual Report for 1906 as follows: "The characteristic flavour of the variety and the rate of fermentation of the juice are the two characters of primary importance as regards the quality of the cider; the percentages of malic acid and tannin in the juice determine the suitability of the variety for use alone or for blending; and the higher the specific gravity of the fresh juice the more useful is the variety, supposing the other characters to be equal." Using these characters to form a standard by which to estimate the value of a variety, a selection of the best varieties which have been tested has been made with the view of recommending their propagation for vintage purposes. The following list includes only those kinds which can be confidently recommended as capable of producing cider of the best quality; but it is by no means an exhaustive one, and will undoubtedly need revision from time to time.

Sharp Varieties.—Cap of Liberty, Red Soldier, Frederick, Dufflin, Foxwhelp, Kingston Black, Dymock Red, Lambrook Pippin.

Sweet Varieties.—White Jersey, Sweet Alford, Slack-ma-girdle, Eggleton Styre, Woodbine, White Close Pippin.

Bittersweet Varieties.—Twistbody Jersey, Royal Jersey, Strawberry Norman, Knotted Kernel, Cherry Norman, Masters' Jersey, Dabinett, Chisel Jersey, Royal Wilding, Major.

This selection is based almost exclusively upon the vintage characters of the fruit, and has no reference to the cropping qualities, the vigour of growth, and other characters which need to be taken into consideration in forming a final estimate as to the value of the varieties. The time is hardly ripe yet for much to be said in that direction, since with few exceptions the varieties have not been widely enough grown to furnish reliable conclusions. Many of the above sorts have been planted in the orchard at the Institute, and the results there up to the present time indicate that Cap of Liberty, Dymock Red, White Jersey, Sweet Alford, Eggleton Styre, Strawberry Norman, Knotted Kernel, Cherry Norman, Masters' Jersey, Dabinett, and Chisel Jersey, are all profitable sorts to grow.

Propagation of Varieties.—All of the above varieties, as well as several old varieties of repute which were in danger of extinction, and a large number of other sorts which have shown promise in the tests in the cider house and the laboratory, are being propagated in the nursery at the Institute. Each season additions are made of those varieties which appear as the result of the current season's examination to merit further attention. As the trees become fit, they are sent out to various centres in the cider-growing districts for trial. Over 7,000 trees raised in this way have already been distributed, the majority of which have been utilised to establish trial orchards under the auspices of the local County Council. There are now 50 of these trial orchards planted at various centres, and their number is being increased annually. In due course they should provide most valuable information as to the suitability of the varieties under trial to different local conditions, and serve as local centres to stimulate interest in the culture of cider fruit and to introduce the best types of vintage apples into each district.

During the course of this examination of the vintage qualities of the fruit several practically unknown kinds possessing distinct merit have been discovered. In all probability these would ultimately have become extinct, if it had not been for this work.

Breeding Experiments.—The propagation of existing varieties of promise is not the only work carried on in the nursery. Efforts are being made to improve upon the existing kinds by systematic breeding experiments, which are being conducted on Mendelian prin-

ciples*. The points to which particular attention is being directed are the increase of the sugar in the juice, the cropping quality and disease-resistant power of the tree, and the time of blossoming. If the latter proves to be a Mendelian factor, very useful work may be accomplished not only from the vintage point of view, but also from that of market fruit culture, since certain cider varieties remain dormant until the usual period of spring frosts is over. Consequently there is rarely any risk of losing the crop from that cause. About 100 young stocks have already been raised from seed resulting from various crosses; and these are now fit for propagation. Another large batch of seedlings will be ready at the end of next summer. If the same measure of success can be attained with fruit as has already been accomplished in the case of some cereals, the results should have a far-reaching influence both on fruit culture and cider-making; although progress must naturally be far slower in working with a slowly maturing plant, like an apple or pear, than with an annual crop of the cereal type.

The Variation in Quality of Individual Varieties.

In dealing with the question of the selection of the best vintage varieties the work has been greatly complicated by the very considerable variations in quality of individual sort which have been met with. Not only does the same variety show appreciable differences in the degree of acidity and astringency and of richness in sugar of the juice, but also in the rate of fermentation of the juice and the flavour and body of the mature cider. It has been found necessary to devote considerable time to an examination of the extent of these variations and the influence of the various factors responsible for them. Considerable progress has been made in some directions; but in other cases little advance can be made, until the trees which have been planted to carry out specially devised experiments approach maturity.

Soil Influence.—One of the most important factors affecting the vintage quality of the fruit is the soil upon which the trees are grown. It is also one of the most difficult for investigation at the moment, since the number of orchards containing trees suitable

* In breeding according to Mendelian principles, attention is concentrated upon the transmission of individual characters rather than upon general effects. It is held that certain associated characters, *e.g.*, tallness and dwarfness in peas, may be regarded as paired; and that when two parents, the one possessing one of these factors and the other the corresponding paired factor, are crossed, the distribution of the respective characters among the offspring follows certain definite and known laws.

for strict comparison on different types of soil is probably very limited ; and in addition—and this remark applies also to all lines of work arising from the investigation of the variation in quality of a variety—there is no satisfactory standard by which the flavour and body of the ciders dealt with can be compared. The best which can be done at present is to procure as much of the fruit of the variety under investigation as is available from the respective centres, to make it up into cider, and then to compare roughly the features of the ciders. It is, however, almost impossible to obtain fruit from each centre in any one season ; and at the best the quantity available is usually very small. Kingston Black is the apple which is being most largely used as the test variety in the investigation on soil influences. It is certainly the most widely distributed and best-known vintage apple grown in this country ; and it has this advantage for the work, —the general characters of the cider made from it are so well known and established that any departure from the general type is easily observed. The variations in the composition of the juice of this variety from different orchards, although appreciable, cannot be described as considerable, except in the case of the percentage of sugar in the juice ; and all could perfectly well be ascribed to the agency of factors other than soil influence. In general, the juices from fruit grown in North Somerset and the cider-producing counties north of Bristol, tend to show a slightly higher degree of acidity than those obtained further south ; but that is the only general statement which can be made, and the result may be due more to climatic than soil influence. The rate of fermentation varies somewhat, but the variations cannot at present be taken as possessing special significance. The type of cider produced is, however, as a rule very characteristic of the district. In the best cider districts of Mid and South Somerset it is rich and full of body, deep in colour and very fruity. The typical Devon Kingston Black cider is much thinner and lighter than the preceding, and paler in colour ; considering the variety, it is comparatively insipid. In North Somerset and the counties to the north of Bristol the cider is of a much brisker type than the two preceding, generally of deeper colour, and more full-bodied than the Devon type, but not so rich nor so deeply coloured as the South Somerset type. These differences are, as far as present experience goes, generally well-marked, and more or less constant ; but the analysis of the juice usually fails to express them to any reliable degree. As suggested above, they may be due to climatic more than soil influence ; but in view of the striking differences between the South Somerset and Devon results it seems probable that the soil influence is not negligible. General

experience, as well as the results of the investigations as far as they have proceeded, points strongly to the probability that the physical structure of the soil has much to do with the type of cider produced. Soils composed to a large extent of particles of a comparatively coarse nature, *e.g.*, typical sandy and gravelly soils, probably generally yield ciders of a thinner and lighter type than heavy soils built up mainly of very fine particles, such as typical heavy loams and clays. The effect may be due to the difference in the moisture-retaining capacities of the soils, the tree being influenced through the roots not only by the amount of moisture but also by the degree of aeration. At present there is no reason to believe that the chemical composition of the soil has much bearing upon the question of soil influence.

Climatic Influence.—Climatic conditions have undoubtedly a very important influence upon vintage quality. The question of latitude, as already indicated in the discussion on soil influence, may play a conspicuous part; but it has not been possible yet to demonstrate its influence, since it has been impracticable to eliminate the effect of soil and other factors. The character of the season has, however, a very definite influence, the direction of which is now well-established. Dry seasons tend towards the production of juices relatively rich in sugar, wet seasons having the reverse effect. Sunny seasons tend towards the production of juices with relatively low rates of fermentation, sunless seasons acting in the opposite way. Sunshine also encourages the formation of sugar in the fruit. The acidity generally is higher, and the astringency less, in wet, sunless seasons. At the same time more probably depends upon the character of the weather at particular periods during the ripening of the fruit than upon the general nature of the season, from mid-August to mid-October appearing to be the critical time for most varieties. The effect of sunshine upon the rate of fermentation of the juices ought not to be overlooked in the practical management of an orchard. In selecting a site it should be borne in mind that it is desirable to catch as much of the daily sunlight as possible. For the same reason it is advisable not to plant the trees too closely, so that each tree may get a full share of the sun; while in pruning the trees the production of dense foliage and close branches should be avoided, so that the fruit may be as much exposed as possible. As might be anticipated, the cider made from fruit on the shaded side of the tree is inferior to that produced from fruit on the sunny side.

The Influence of the Vigour of the Tree. —The vigour of growth of the tree appears to be another factor of considerable importance

in influencing vintage quality, its effect seeming at first sight to be exactly opposite to what might have been anticipated. Instead of high vintage quality being associated with vigorous growth, it has been found that generally better cider can be produced from old trees, more or less at a standstill as regards growth, than from young trees of the same variety in full vigour of growth. This result is effected, firstly, by the juices from the old trees being richer in sugar than those from young trees, and, secondly, by the rate of fermentation being slower in the former case. Not only does this feature hold good generally for trees of the same variety, but it may also be applied with a considerable degree of accuracy to trees of different varieties. If a list is made of varieties placed as closely as possible in order of vigour of growth, it is remarkable how nearly it resembles in order a list of the same varieties arranged according to vintage merit, the strongest growers corresponding in position with those of lowest vintage quality.

It is to be expected, in view of these results, that anything affecting the vigour of growth of a tree would also influence the vintage quality of its fruit; but, although several lines of inquiry are receiving attention, there is not yet much to report in the way of definite results. Possibly the fact that all the trees under investigation are still very young may account for conflicting results. Among such lines of inquiry which have been discussed in recent Annual Reports are the character of the root-stock, the nature of the intermediate stock,—in cases where the variety under consideration has been head-worked,—and the growth of the trees in cultivated and grass land.

The Influence of Ripeness.—The condition of ripeness of the fruit at the time of milling is a factor of primary importance, the quality of the juice being considerably affected. It has long been known that during the process of ripening the juice grows richer in sugar, while at the same time the acidity diminishes. After a certain point, which may be considered the optimum point of ripeness, the amount of sugar in the juice gradually decreases and the acidity continues to be reduced. The mucilaginous elements of the fruit also undergo a series of characteristic changes, which render the expression of the juice more and more difficult as the condition of over-ripeness developes. While these variations have an appreciable effect upon the quality of the cider, other changes at work, which have been observed during the course of these investigations, have a still greater influence.

The most important from the practical cider-maker's point of view are probably those concerned with the nitrogenous con-

stituents of the juice which are available for the nutrition of the yeast. The quantity of these substances gradually diminishes during the course of ripening, until at the point of optimum ripeness they reach their lowest limit. They then begin gradually to increase in quantity again as the fruit becomes over-ripe. Consequently the rate of fermentation of the juice varies in the same manner. The juice from the unripe fruit ferments comparatively rapidly; the rate then gradually decreases until the point of optimum ripeness is reached, after which it begins by degrees to increase again. The "body" of the cider produced is also affected, the liquor becoming more full-bodied, according as it is made from fruit approximating to the optimum degree of ripeness.

The changes in the mucilaginous and pectic constituents of the juice are also important for practical purposes. Not only is the ease of expression of the juice concerned, but also the property of natural clearing or "fining" of the liquor, as well as the ease of filtration. Apples of the sweet and bitter-sweet classes, with acidities ruling not much above .2 per cent., will yield juices which quickly "drop bright," *i.e.*, clear naturally by the formation of a jelly-like clot of pectic material, if the fruit is pressed when it is at the stage of optimum ripeness. If pressed earlier, the cider will not "fine" naturally until fermentation is complete; while, if dealt with later, although a considerable amount of natural clarification may be effected at an early stage by the precipitation of a copious mucilaginous deposit, there is often a certain amount of opalescence remaining, which is exceedingly troublesome to get rid of. Apples of the sharp class do not as a rule behave in this manner; although in the case of certain varieties, *e.g.*, Dymock Red, Frederick, Foxwhelp, and Duffin, a somewhat analogous clotting action has been observed. In these instances the clotting appears to occur most strongly in the juices obtained from fruit somewhat on the over-ripe side. These clotting actions are much more striking in some seasons than in others; and they are rarely well-developed in practical cider-making unless the lot of fruit dealt with is in an even condition of ripeness. It is a matter of general experience that ciders which drop bright in this fashion, if racked carefully at the critical moment, are much more easy to manage afterwards than those in which no clotting takes place, and are also of decidedly superior quality.

Vintage Orchards and their Management.

The results of the investigations as to the character and the quality of vintage fruit afford many indications as to the

correct lines on which to work in practice in order to obtain juices of high vintage quality. In a few cases, such as where climatic conditions and the nature of the season are concerned, control is beyond the power of the grower or maker; but with these exceptions he is able to exercise a very large measure of command over the character of his produce. It is true that to carry into practice the principles elucidated by these investigations must involve sweeping changes in the present system of vintage orchard culture and management; and that is a matter of slow development, and one from which the present generation of cider makers can hardly expect to derive full benefit. They have to deal with the existing state of things, and make the best of them. It will, however, be seen in the following review of the manner in which these principles may be applied to practical problems, that there are many points which directly affect the grower and the maker of the present day.

The Selection of Varieties.—Starting at the beginning of orchard work, viz., the planting of a new orchard, there are several points upon which light has been thrown. The selection of the best varieties is the first consideration; and with the amount of knowledge now at our disposal there is little difficulty in making a selection which can be relied upon to produce in due course cider of the best quality possible to the local conditions. The varieties selected should not only be of the best quality: due regard in making the selection should be paid to their adaptability for blending with one another; and the proportions of each type should be adjusted so that the result will be a well-balanced cider. If the orchard is a small one, it is important that all the varieties selected should ripen at the same period, so that gathering may be facilitated and the orchard closed for grazing purposes as short a time as possible. In larger orchards it is desirable, for convenience in gathering, to keep together those varieties which ripen at the same time. Trees of the same variety should adjoin one another in rows rather than in blocks, in order that cross-fertilisation may be facilitated and heavier crops thus ensured.

The Influence of Grass.—After planting, the young trees should be kept free from grass around the roots for at least two or three seasons. The experiments in the young orchard at the Institute show conclusively that stronger growth is made under such conditions than when the grass is allowed to grow right up to the base of the tree. Whether the removal of the turf has any influence upon the vintage quality of the fruit is not yet certain; but in view of the manner in which the vigour of growth of the tree affects vintage

quality, it appears likely that the usual custom of growing vintage fruit grass orchards is superior for cider purposes than an orchard in cultivated ground.

Head-grafting.—Since some of the best vintage varieties are, as already indicated, comparatively weak growers and make poor standard trees if propagated in the usual way, they are sometimes head-grafted on a tree of a strong-growing variety. The experiments at the Institute have shown that the growth of the tree is considerably checked for a few seasons by this treatment, and that the check is much more severe if the grafting is delayed two years after the planting of the original tree than if it is done one year after planting. It has not yet been determined definitely whether the vintage quality of the fruit is affected by the nature of the variety upon which it is head-worked.

Pruning. The much debated question of the pruning of standard trees after planting is still under investigation. In several of the new trial orchards, at various centres, the relative merits of pruning the first spring following planting, or the next year, are being tested. At the Institute experiments made on the severity of this pruning show that the hardest pruned trees have generally failed to make as much headway as those pruned more lightly; while in the majority of instances, those pruned the first spring after planting have made better trees than those pruned a year later. The nature of the pruning in the succeeding seasons also is important on account of its subsequent effect upon the vintage quality of the fruit. The object must be to expose the fruit to the sun as far as possible.

The Re-planting of Old Orchards. The re-planting of old orchards is a practice which is insisted on in many places. As gaps have arisen in the old orchard at the Institute, they have been filled with young trees; and the result by comparison with similar trees in the young orchard adjoining is poor. For many reasons the practice is an undesirable one; but an interesting result has been noticed. The juice from the young trees in the old orchard ferments more slowly than from those in the new orchard; and the probability is that, when they begin to bear more freely, better cider, for a time at any rate, will be produced from the former. This result, it will be noted, is quite in accordance with others in which the question of the vigour of growth of the tree is concerned.

Bush Plantations.—In view of the long period of waiting for the trees to come into profitable bearing, which is such a strong deterrent to the planting of new vintage orchards, suggestions have been put forward for a trial of cider varieties grown on the Paradise stock in bush form, as is the common practice for market varieties of

apples. A plantation on those lines has been laid down at the Institute in cultivated soil ; but it is too early yet to look for any definite results. It may be anticipated that the difficulty of the long period of waiting for the crop will be overcome ; but there are evidently strong objections to the system, not the least of which is the relatively short life of such a plantation. The effect of the Paradise stock on the vintage quality of the fruit is one of the points of principal concern ; and, as far as present indications go, there does not appear to be much influence upon the composition of the juice, although, perhaps, the rate of fermentation shows some tendency to be rather more rapid than that from fruit grown under the usual conditions.

The Management of Vintage Fruit.

The Harvesting of the Fruit.—The orchard management of the fruit is undoubtedly of the highest importance from the vintage point of view. The conditions under which it is harvested have a great bearing upon the quality of the cider made from it. There are two main points to be considered : firstly, the gathering of individual varieties separately ; and, secondly, the collection of the fruit in as sound and as evenly ripe condition as possible, so that it may be stored for the necessary period of time without detriment. Unfortunately, the common practice is to neglect both of these most essential matters. The first point must be attended to, if blending on a sound basis is to be adopted. It would doubtless receive greater consideration but for the fact that it is unusual to find in any one orchard any considerable bulk of the same kind of apple. Consequently arrangements to keep the sorts separate are troublesome and result in the collection of a large number of parcels of small bulk. In some cases there is little which is worth doing in this way. There ought, however, to be no trouble of this kind in the orchards of the future, since the desirability of planting few sorts is now generally recognised. Contrary to the old ideas, it has been demonstrated that it is not correct to assume that the greater the mixture of kinds the better is the blend.

Some mention may here be made of the prices of different varieties of cider fruit. Individual varieties vary so greatly in quality that more attention should be given to the principle of variation in price according to vintage value. If this were more generally done, considerable stimulus would be given to growers to gather the varieties separately. It may be taken as a general principle that that mixed fruit ought not to be able to command such good prices as that separated according to variety ; while individual sorts should

fetch prices corresponding with their vintage value. To some slight extent this is gradually being recognised; and a few varieties, of which Kingston Black is the most conspicuous example, are now largely dealt with in this fashion. It may be claimed that the work of the Institute has brought this matter more prominently forward, and has furnished about many kinds information on which an estimate of their relative values may be based.

If attention is given to the separation of the varieties, the second point in connection with the harvesting of the fruit, viz., the collection of the fruit in as sound and evenly ripe condition as possible, is rendered more easy of accomplishment. For the great majority of sorts storage for some period of time after gathering is essential, if they are to be brought to the mill in the best condition for vintage purposes: and such storage is impossible, without running risks of taints in flavour from decomposed fruit, unless the sample of fruit is approximately of the same degree of ripeness and as free as possible from bruises and other damage. Care in gathering the fruit is the means by which this object may be attained; and in particular cases the use of a harvest blanket is to be recommended. At the same time in most instances sufficiently satisfactory results can be obtained by gathering the fruit in the usual manner, if care is taken. The fruit ought never to be forced from the trees. It will readily fall when fit, if the trees are lightly shaken. It should not be allowed to lie on the ground for any length of time, and when being picked up, all seriously damaged specimens should be separated from the sound apples.

The Storage of Vintage Fruit.—The storage of the fruit is necessary in order that it may have time to undergo those changes in ripeness which bring it to the condition of maximum quality for vintage purposes. The question as to the best methods of storage has been much discussed, and a number of experiments have been carried out at the Institute. They gave results which proved that, provided the fruit is protected adequately against unfavourable climatic conditions, such as frost or excessive rain, and is not allowed to lie directly on the ground,—to avoid the risk of an earthy taint in the flavour,—the exact details of the method of storage have comparatively little influence upon the character of the cider. Undoubtedly the nature of the weather during the course of storage has much influence on the results, especially when outdoor storage and storage under cover are being compared, so that they vary somewhat from year to year. In any case, the heaps should not be deeper than three feet, on account of the liability of the fruit to “heat”; and for the same reason good ventilation through

the heap is desirable. For storage under cover the fruit should be gathered in as dry a condition as possible, since wet fruit under cover is especially liable to "heat."

The length of time of storage which is desirable varies not only according to the variety of fruit, but also according to the weather conditions, the temperature in particular having much influence. The decision as to the time at which the fruit is at the best condition for grinding is a critical one, since the quality of the cider is directly dependent on it. Unfortunately there are no general tests known which can be applied with any degree of certainty; and it is, therefore, a matter which must be left largely to the experience of the cider-maker. The quantity of juice obtainable from the fruit, as well as the quality, is affected by the condition of ripeness at the time of milling. The results of experiments indicate that, under the usual conditions of storage, the period during which the fruit is at its best condition for milling is of about a fortnight's duration.

The Washing of Cider Fruit.--Although care may be taken during the harvesting and storage of the fruit, it frequently happens that there is an appreciable amount of dirt and foreign matter mixed with it; and while in the average case this probably has no detectable effect on the cider, there are occasions when a distinct taint in the flavour is noticeable. This danger may usually be avoided by washing the fruit before milling it. A number of trials made at the Institute show that washing is very serviceable in assisting the production of a perfectly clean cider; but at the same time it is accompanied by some drawbacks. It is, for instance, advisable that the fruit should not stand longer than 24 hours after being washed before being milled, on account of liability to acetification in its wet condition. On the other hand, it cannot be milled immediately after washing without the specific gravity of the juice being somewhat lowered by the water still adhering to the fruit. Some time should, therefore, be allowed for it to drain. The actual washing of the fruit is not easy unless special arrangements are made, and a good and abundant water supply is essential. Where large quantities of fruit are handled, it would probably pay to wash it; but the small maker would perhaps find it better to devote his energies to gathering and storing the fruit in the cleanest possible manner.

Methods of Cider-Making.

Passing on to the various operations and phases of cider-making proper, it may be stated that the experiments have, on the whole, shown them to have surprisingly little influence on the quality of

the cider—provided that the treatment adopted is not irrational—except in so far as the regulation and control of the rate of fermentation and, accordingly, of the sweetness or dryness of the cider are concerned.

Cider-making Machinery.—Since there are now several types of cider-making machinery on the market, it has been important to ascertain to what extent, if any, the kind of machine used affects the cider. The experiments which it has been possible to make in this direction have been necessarily comparatively restricted; but the general results appear to be trustworthy. It may certainly be considered established that contact at any stage during the production of cider between the fruit or the juice and metals of any description—referring, of course, only to those commonly used in the construction of cider-making machinery—should be reduced to a minimum. Apple juice or cider which has been in contact with any metallic surface, has almost invariably an appreciably harder or more metallic character in its flavour than that which has come into contact with wood, stone, or glass only. Some metals, such as iron, which are relatively quickly acted on by malic acid, produce very noticeable effects: and, as would be expected, juices with relatively high acidity suffer worst. In the construction of all cider-making machinery, where it is necessary for the fruit or juice to come into contact with a metallic surface, arrangements should be made so that the surface of contact is as small and the time of contact as short as possible.

There are considerable differences in the yield of juice obtainable from the various types of cider-making machines; and the nature of the mill used is probably the most important factor in this connection. While it is necessary to disintegrate the fruit as completely as possible to get the highest yield, the manner and character of the disintegration are of influence. Classing the various kinds of mills into two main types, the "crusher" and the "grater" types, the kind of disintegration obtained in the respective cases differs considerably; and it is easier to express the juice from the "grated" pomace of the latter type of mill than from the broken and crushed pomace of the former kind. Against this, however, must be set other differences of action. The juice obtained by the use of a "crusher" mill is as a rule appreciably fuller in flavour and softer in character, and contains more dissolved mucilaginous and pectic substances than that from a "grater" mill. The juice in the former case generally also carries more suspended solid matter. Other factors affecting the yield of juice are the nature and power of the press, and the manner in which the "cheese" is built up; but they have not been shown to have any influence on the quality of the juice.

The Variation in Quality of the Juice during Pressing.—The kind of machinery used has probably also some influence upon the quality of juice, as it runs from the press, at different periods during the pressing of the cheese. Some cider-makers state that the first runnings from the press are in their case the richest, and that as the pressing is continued the quality deteriorates. Other makers appear to get the opposite experience, and find that the poorest juice comes first and the richest last. The Institute experiments, in which a machine of the "grater" type was used, showed that different cheeses varied considerably in this respect, sometimes the first, and sometimes the last runnings being the richest, while occasionally the middle runnings were superior to either. The conclusion arrived at was that for machinery of that type the condition of ripeness of the fruit at the time of milling was responsible for the kind of result obtained. While the same cause is doubtless also of considerable influence where mills of the "crusher" type are used, there is reason for believing that the results are more regular in such cases, and that generally either the first or the last runnings are the richest, according to the exact kind of machine used. In referring here to the richness of the juice, this term should be understood as meaning the juice which yields the richest cider. Individual characters of the juice vary considerably at different periods of the flow from the press. Both the specific gravity and the rate of fermentation show appreciable variations, more or less in accordance with those already described in connection with the general term "richness." The acidity varies but little; but in nearly all cases the first runnings are the richest and the last the poorest in tannin, due to the gradual oxidation of this substance by exposure to air.

The Maceration of the Pomace.—These remarks as to the quality of the various runnings of juice apply only to cheeses made up with pomace taken direct from the mill. Some makers prefer to allow the pomace to stand for several hours or even two or three days before pressing it. This treatment may be referred to as "maceration." It is doubtful at present how far the quality of the runnings vary after such treatment. Maceration was at one time widely practised owing to the belief that the juice obtained in such cases was decidedly richer than that from pomace pressed immediately. Recent experiments have shown that the importance of maceration from this point of view has been much exaggerated. There is certainly a slight tendency on the whole for the juice to be of better quality; but, although in some cases the difference may be appreciable, there is rarely any material alteration. The juice is, however,

more easily and quickly expressed from macerated pomace ; and the yield is generally rather greater. On the other hand, the method involves a little more labour and trouble, and there is always more risk of contamination. Some investigations which have lately been started and are still in progress, and which are mainly concerned with the mucilaginous elements of the juice, promise to throw further light upon the reason which caused maceration to be regarded with favour. There are differences in the mucilaginous constituents of juices from unmacerated and macerated pomace ; and it seems probable that racking may be considerably more effective in checking fermentation in the latter case than in the former on that account. If so, it will be understood why, in the days before the filter was in common use, when control of fermentation depended mainly upon racking, it might have been possible to make a richer cider after maceration, if such were actually the case. As far as the results at present go, it is undoubtedly the case that the juices and ciders which have been allowed to macerate in the pomace for eighteen hours or more have been more easily and thoroughly filtered than those which have not been macerated. In some of the experiments maceration in the ordinary sense has been supplemented by the actual fermentation of the juice in the pomace by allowing it to stand for a period of several days before pressing, and by the addition of a quantity of yeast. Filtration of the juice or, more strictly speaking, of the cider immediately after pressing has then been possible with ease, whereas juice or cider of the same kind dealt with in the usual way and in the corresponding stage has been difficult to filter. Consequently, in the former case it has been possible to check fermentation at a much earlier stage. The method promises to prove of considerable value in dealing with varieties subject to rapid fermentation ; but the effect upon the flavour and keeping qualities of the ciders has not yet been settled.

The Colour of Cider.—The method of dealing with the pomace before the juice is finally expressed has some bearing also upon the colour of the cider. Generally speaking, the greater the exposure of the pomace to air the deeper is the colour of the juice. The type of mill used has for the same reason considerable influence. While much of the effect is temporary only, the extra depth of colour disappearing more or less completely in course of fermentation, the general tendency is for the cider from exposed pomace to be rather deeper in colour than that from pomace which has been little exposed. The colour, other factors being equal, depends upon the amount of carbon dioxide in the cider, the more highly charged

it is with the gas the paler being the colour. This is due to the deoxidising or reducing properties of the gas, certain substances in the cider which are deeply coloured when combined with oxygen becoming much paler or colourless when the combination with that element is broken up by means of the action of the carbon dioxide. If the latter gas is allowed to escape, the colour becomes deeper again. The chemistry of the colour of cider is too complicated for treatment here ; but it may be stated that as a general rule ciders containing a relatively large amount of tannin are deeper in colour than those containing small amounts of that substance, while the reverse is the case with malic acid. At the same time the tannins are probably not alone responsible for the colour ; for there is evidence that there are other chromogenic substances present in the freshly expressed juice which are of more importance.

*Keeping.**—There has been great difference of opinion among cider-makers as to whether the practice of keeving the freshly-expressed juice is beneficial or otherwise. The solution of this question, as indicated by the results of the experiments at the Institute, appears to be, as in many other matters in dispute, that no general rule holds good. In certain cases keeving has proved beneficial, and in other instances useless or even detrimental. The nature of the results will depend upon the circumstances of the particular cases. Keeving, generally, is useful where juices containing much suspended solid matter are concerned. Some of the older types of cider-making machinery regularly yield juices in this condition ; and where such are used, keeving may with advantage be regularly adopted. Many of the newer types of machines give juices holding so little solid matter in suspension that keeving is for the average juice quite unnecessary. In special cases, however, when the nature of the fruit used makes it probable that a jelly-like clotting of the mucilaginous constituents at an early stage of fermentation will occur, it is useful to keeve the juice ; since, after the clotting has taken place, the clear liquor, when it has “dropped bright,” can be racked more carefully and under better conditions than from the usual fermenting cask. Keeving does not appear to affect the flavour of the cider to any extent ; but it

* “Keeving” consists in allowing the freshly pressed juice to stand for several days in an open vat or cask until a “head” has been thrown up. This is eventually skimmed off and the juice then carefully racked into the fermenting cask. By this means the greater part of the solid matter in suspension in the juice is quickly got rid of, since it quickly rises to assist in forming a “head,” or is deposited on the bottom of the keeving vessel.

causes fermentation to set in more quickly, and to proceed for a time more rapidly, on account of the greater aeration of the juice.

Cask Influence.—After keeving is completed, the juice is racked into the fermenting cask; or, if it is not keeved, it is placed there direct from the press. It depends upon the management from this stage onwards whether a dry or sweet cider is produced. In practice trouble is often caused by the variation in behaviour of different casks of the same juice; and it is the usual experience to find that the cider produced is in no two cases exactly alike, although the same juice was used to start with. The cause must be attributed mainly to the effect of the individual casks; and it is difficult to see how the trouble can be obviated. This factor has a most disturbing effect upon the experimental work on a practical scale in the cider house on account of the difficulty of ascertaining how much allowance must be made for it in the results. The structure of the cask, and the character and condition of the wood of which it is built, are responsible, in part at least, for this influence. This may be seen on any occasion when the juice is keeved and a white head thrown up. The first indications of the head are visible in the form of lines of froth on the surface of the juice, which correspond exactly with the joints of the staves on the bottom of the cask used as a keeving vessel. The aeration of the juice varies undoubtedly in different casks; and the rate of fermentation is therefore affected. Among other ways in which the cask may exert influence upon the contained juice is that by means of the living germs which may be present in the crevices of the wood. It is difficult, if not impossible, to absolutely sterilise a cask before use; and, consequently, any germs which may be living at the time the juice is introduced may cause appreciable alterations in the character of the cider.

The Practice of Sulphuring. It is therefore obviously desirable to make an effort to sterilise as thoroughly as possible any cask before use. At the Institute they are first soaked with bisulphite of lime, which is removed by washing; and they are then well steamed immediately before use. The purification of casks by burning a sulphur match within them is a very old custom, and is useful on account of its simplicity. Since, however, the juice is generally introduced without the fumes of the sulphur being washed out, their action upon the juice requires consideration. Sulphur in this form, (sulphur dioxide), possesses marked antiseptic properties, and therefore tends to check fermentation in the juice for a time. It is hardly fair, however, to class it with other preservatives commonly utilised, the addition of which is not recommended; for its use has been regarded as legitimate from the earliest times, and its effect is

temporary only, owing to its gradual conversion into other substances. At the same time, if its use is sanctioned, the amount allowed to be used should be defined by law. Some interesting results have been obtained at the Institute with regard to its action on apple juice and cider. The size of the dose required to check fermentation for a given period varies according to the juice, the more rapid the natural rate of fermentation of the juice the larger the dose required. After the effect of the dose—which is temporary only, if the strength is not excessive—has passed off, the rate of fermentation proceeds as rapidly as though no sulphuring had been done. No doses are powerful enough to arrest fermentation for a long period without leaving a taste and aroma of the sulphur dioxide so strong as to render the liquor less palatable. After the taste of the sulphur dioxide has passed off in a sulphured cider, the flavour is still radically different from that of an unsulphured one, partly owing to the combination of a portion of the sulphur compound with certain substances produced in the cider as a result of fermentation. Undoubtedly, also, the fermentation, after sulphuring, is of a purer character and less affected by harmful germs than that of an unsulphured cider. The sulphuring of fresh juice may also prove useful on account of the opportunity of a natural clearing of the juice being effected by the action of the mucilaginous constituents, before these are affected by fermentation.

The Organisms of Fermentation.—It is the usual practice in cider-making to allow fermentation to develop spontaneously in the juice. The organisms which carry on the work of fermentation find their way into the juice partly from the fruit, and partly from the portions of the cider-making machinery and other appliances and vessels with which the juice comes into contact. Some also doubtless reach the juice from the atmosphere of the cider-making premises. Investigations have shown that there are normally at least from six to a dozen different kinds present in sufficient number in the early stages of fermentation to affect its character. The actual varieties of yeast present vary considerably in different juices; and since their presence is, as a rule, more or less the result of chance and is uncontrolled by the maker, the exact character of the fermentation is a matter of accident and cannot invariably lead to the best result. It may, however, be granted that in the average case the results are not unsatisfactory, and are not markedly inferior to those obtained when the character of the fermentation is controlled by special treatment. Researches conducted in France some years ago showed that in French ciders the predominating types of yeast varied according to the stage of fermentation; and

corresponding investigations at the Institute have given similar results for English ciders. It has been proved that in the latter, during the earliest stages of fermentation, the predominating forms mainly belong to the group known as *Saccharomyces apiculatus*. These gradually decrease in number, and eventually, after several weeks, practically die out as fermentation progresses; and a few other types possessing greater powers of resistance to the effect of alcohol then take their place. According to some authorities, the type of fermentation produced by yeasts of the *apiculatus* type is of a satisfactory character; but, on the whole, their influence is now considered detrimental rather than otherwise, except possibly in special cases.

Two lines of attempting to control the character of the fermentation and of avoiding the action of undesirable yeasts and bacteria, such as the *apiculatus* forms, have been investigated. The first method is to prevent the development of the undesirable forms in the juice, either by preventing their entry into the juice by sterilising, more or less thoroughly, the fruit and the cider-making appliances and vessels by washing with an antiseptic, as recently suggested by certain French scientists, or by paralysing their growth in the juice by adding to it a sufficient quantity of an antiseptic, such as sulphur dioxide, the effects of which are temporary only and pass off in time to allow fermentation to proceed as required. By such treatment the undesirable yeasts and bacteria appear to suffer more than those of greater value, and consequently the character of the fermentation is improved. Further investigation is, however, required before the method may be advocated for general use. The second method consists in the addition to the fresh juice of a quantity of a selected yeast or a mixture of yeasts sufficient to dominate the fermentation and keep under the development of the organisms naturally present by crowding them out. A great deal of work has been done along these lines, both abroad and in this country; and several trials have been made by the makers themselves, as well as at centres of investigation, such as the Institute. Wine and brewery yeasts, as well as cider forms, have been tested. The results have been very variable, not only with different yeasts, but also with the same yeast on different occasions; and the general experience seems to have been that, except under special conditions and for particular purposes, the results hardly justify the extra trouble and expense. One of the principal obstacles against success is that the characters of the juices which are used are so variable that, although one yeast or combination of yeasts may give good results with juices of a particular type, it may prove unsatisfactory with

juices of another type. With a more uniform type of raw material to work upon more regular results could be expected; and in course of time, if the orchard conditions improve, the use of selected yeasts might profitably be generally adopted.

Temperature Influence.—So far very little attention has been paid to the temperature at which the cider is fermented, the general plan being to allow it to proceed at the ordinary temperature of the cider-house, which varies, as a rule, during the cider-making season between about 35°F. and 55°F. A low temperature has been almost universally regarded as giving the best results; but recent work at the Institute has thrown doubt upon the correctness of this view, and appears to indicate that temperatures between 60°F. and 75°F. give better results for the period of active fermentation than lower temperatures, on account of the reduction of the influence of undesirable organisms caused by the increased vigour of action of the yeasts.

The Control of Fermentation.—With regard to the management of the juice during the course of active fermentation the investigations have shown that such differences of treatment are necessary according to the kind of cider under consideration, that it is difficult in the limited space at disposal here to summarise the results adequately. For a special account of this subject reference should be made to Leaflets Nos. 2 and 3, published by the Institute. Briefly, the kind of treatment adopted should be regulated by the rate of fermentation of the juice and by the type of cider which it is desired to produce. The same kind of treatment with two distinct juices will not give the same results. If a sweet cider is desired, in favourable cases it may be produced simply by racking; but the natural rate of fermentation of the juice must be very slow, if racking alone is to be relied upon. Filtration is necessary for this purpose in most cases; but even that is not always effective if the rate of fermentation of the juice is rapid, and in such cases the juice is best adapted to make a dry cider. The point at which an attempt to check fermentation by racking or filtration should be made, similarly depends upon the rate of fermentation of the juice.

Blending.—As already shown, blending is necessary for most varieties of vintage fruit. This is generally done by mixing the fruit of different kinds together in suitable proportions; but the work at the Institute tends to favour the blending of juices or ciders rather than that of the fruit. Where the varieties are gathered and stored separately, and their qualities are well known, the blending of the fruit may be advocated as being the simplest plan, and likely to give no complications later; but in other cases better results

can generally be obtained by blending the juices or ciders. If blending is delayed till this stage, there is no risk of loss of quality by mixing sorts of good and indifferent vintage value, since the required information as to the quality of the juices can be obtained before blending has to be done: and at the same time blending can be done exactly to taste. Experiments have also shown that the flavour of ciders blended after fermentation is in no way inferior to that of corresponding blends made in the fruit stage. Care, however, must be taken to blend only ciders whose rates of fermentation more or less correspond. If ciders which have fermented rapidly are blended with others which have fermented slowly, or dry ciders with sweet, there is considerable liability to renewed fermentation.

Bottling.—A number of useful facts with regard to the question of the bottling of ciders have been ascertained. If ciders are bottled too early, they throw a heavy deposit of yeast, often mixed with more or less mucilaginous material, degenerate in quality after a time, and produce too much gas in bottle. If they are bottled at the right time, the deposit is very limited, just sufficient gas is generated to make the cider nicely sparkling, and the quality improves rather than deteriorates. If they are bottled too late, little deposit is thrown down, but many troublesome “fliers,” or pieces of floating matter, make their appearance, very little gas is generated, and often some acetification occurs. The correct time for bottling varies greatly according to the character of the cider. Ciders made from juices with slow rates of fermentation can often be bottled successfully as early as the February after making, especially if prolonged storage in bottle is not desired; ciders with moderate rates of fermentation are usually best bottled in April or May; while dry ciders which have fermented rapidly, but still retain a small quantity of sugar, need not be put into bottle before midsummer, except as required for almost immediate consumption. The character of the deposit varies greatly with the type of cider, those with low acidities giving typically a loose, easily disturbed, flocculent deposit, and those with relatively high acidities giving a firm, solid deposit, not easily disturbed.

Disorders of Cider.

Some attention has been paid to the disorders to which cider is liable, their nature, and possible methods of treatment for their prevention or for the amelioration of the ciders attacked. The two disorders which are most prevalent and which are responsible for the most serious damage, viz., acetification and sickness, are

those to which most attention has been paid, and in connection with which practical results of most value have been achieved.

Acetification.—Acetification can, and should, always be avoided by proper management until the heat of the summer begins to have its effect on cider in cask, provided that the juice is sound to start with. At times, however, the fruit “heats” before it is milled, in which cases the taint of acetification is perceptible in the juice from the beginning. Generally, also, many ciders stored in cask throughout the summer show appreciable signs of acetification. Decided benefit has been derived in such cases by the method of “re-soaking,” which consists simply in mixing the affected cider with the pressed pomace, taken from a cheese after as much as possible of the juice has been expressed in the usual manner, until the cider is well soaked up by it. The proportion of old cider to be added to the pomace should be varied according to circumstances, but generally it may be taken at the rate of 10 gallons of cider to 200 lbs. of the pressed pomace. The mixture is allowed to stand overnight in a wooden vat; and on the following day is built up into a cheese, and as much of the liquor as possible expressed. This then consists of a mixture of the old cider with the residual juice of the pomace, and will be found to have lost to a very great degree the “acetified” taint in flavour. It may be filtered at once, the filtration being repeated if renewed fermentation should begin; or it may be allowed to ferment for a short time before being filtered. In either case the final product is a marked improvement upon the original tainted cider, and is a readily marketable article. The cost of the process is very small, being limited to the expense of labour involved in the process; while use is made of the residual juice in the pressed pomace, which would otherwise be discarded.

Sickness.—Cider sickness is a difficult disorder to combat, being due to the action of organisms which occur naturally in the fresh juice and remain more or less dormant until favourable circumstances give them a chance to develop. The factor usually responsible for the beginning of the disorder is a high temperature, ciders liable to be affected generally remaining apparently sound until a spell of warm weather sets in. Then the characteristic flavour of sickness develops, and generally a tumultuous fermentation starts. The quality of the cider is ruined. The investigations have shown that generally only those ciders made from juices possessing a naturally slow rate of fermentation are affected. By blending such juices with others having a more rapid rate of fermentation the trouble may frequently be avoided, although this does not appear to answer in every

case. It has been found, also, that ciders of relatively high acidity are comparatively immune: so that the use of a good proportion of sharp fruit, or of a brisk cider, in a blend is to be recommended in cases where trouble from the disorder is anticipated. A third method of combating the disorder has recently been discovered; but, while it has given very promising results in the particular cases tested, sufficient experience has not yet been gained to allow of a final decision as to its real efficiency. Most ciders attacked by sickness are of very good quality, being up to "bottling" standard: and the remedy proposed is that they should be bottled at a much earlier period than usual. It has been observed that aeration of the cider has considerable influence on the development of the disorder: so it was thought that if the ciders were bottled in late winter or very early spring, instead of in April according to the usual practice, they would suffer less from aeration influence, and might accordingly escape the disorder. Fortunately, from other points of view, bottling at such an early date is practicable for such ciders, since, owing to their character of slow fermentation, they do not develop too much condition in bottle nor throw too much deposit. The results of the trials last season were very conclusive as far as they went, showing that the March bottlings escaped the disorder to a large extent, and resisted it better than the April bottlings of the same cider; and these in turn, while eventually succumbing, resisted it for a longer period than later bottlings.

INVESTIGATIONS ON MARKET FRUIT CULTURE.

Reference has been made in the foregoing pages to a number of investigations concerned with the culture of fruit trees, in so far as they apply to vintage as well as market fruit. Others referring more particularly to market apples and pears, as well as other varieties of fruit, have also been carried on. In several instances the time is not yet sufficiently advanced for positive results to be available; so that reference will only be made in the following summary to those which have furnished results.

Variety Trials.—Variety trials with a number of kinds of fruit are in progress in the fruit plantations at the Institute. The following lists summarise the results as far as showing the suitability of the varieties tested to the soil and other local conditions at Long Ashton. The kind of soil on which the plantations and orchards are established is a somewhat stiff, deep, sandy loam on the Old Red Sandstone formation. It is evidently a rich soil, and promotes an exceptionally vigorous growth of most kinds of fruit trees.

- APPLES. *Good* : *King of the Pippins*, *Lane's Prince Albert*, *Ecklinville*, *Bismarck*, *Lord Derby*, *Lord Grosvenor*, *Sturmer Pippin*, *Wealthy*, *Newton Wonder*.
Moderate : *Allington Pippin*, *Cox's Orange Pippin*, *Worcester Pearmain*, *Newton Wonder*, *Stirling Castle*, *Warner's King*, *White Transparent*, *Frogmore Prolific*, *James Grieve*, *Rival*, *Beauty of Bath*, *Devonshire Quarrenden*.
Poor : *Lord Suffield*.
- PEARS *Good* : *Doyenne Boussoch*, *Louise Bonne de Jersey*, *Conference*, *Pitmaston Duchess*, *Emile d'Heyst*.
Moderate : *Williams' Bon Chretien*, *Catillac*.
Poor : *Hessle*, *Triomphe de Vienne*, *Durondeau*.
- GOOSEBERRIES *Good* : *Keepsake*, *Whinham's Industry*, *King of Trumps*, *May Duke*, *Surprise*, *Langley Gage*, *Careless*, *Leader*, *Leveller*, *Telegraph*.
Moderate : *Lancashire Lad*, *Faithful*, *Fascination*, *Mount Pleasant*, *Diadem*, *Falstaff*, *Red Warrington*, *Gretna Green*, *Dan's Mistake*, *Victoria*, *Red Champagne*, *Transparent*.
Poor : *Crown Bob*, *Blucher*, *Early Sulphur*, *Golden Gem*, *High Sheriff*, *Hero of the Nile*, *Ringer*, *Thatcher*.
- RED CURRANTS *Good* : *Fay's Prolific*, *Raby Castle*, *New Red Dutch*, *Knight's Sweet Red*, *Cherry*, *Comet*.
Moderate : *Red Cross*, *La Versaillaise*, *Red American*, *Red Grape*, *La Fertile*.
Poor : *La Hative*.
- WHITE CURRANTS *Good* : *White Dutch Cut Leaf*, *White Versailles*.
Moderate : *White Dutch*, *La Transparent*, *White Transparent*.
- BLACK CURRANTS *Good* : *Ogden's Black*, *Boskoop Giant*.
Moderate : *Goliath*, *Victoria*.
Poor : *Black Prince*.
- RASPBERRIES *Good* : *Norwich Wonder*, *Northumberland Fillbasket*, *Semper Fideles*, *Lord Beaconsfield*, *Baumforth's Seedling*, *Superlative*, *Red Antwerp*.
Moderate : *Hornet*, *Yellow Antwerp*, *White Magnum Bonum*, *Abundance*, *Carter's Prolific*.
- STRAWBERRIES *Good* : *Royal Sovereign*, *Givon's Late Prolific*, *President*, *Monarch*, *Sir Joseph Paxton*, *Vicomtesse Hericart de Thury*, *Leader*, *Trafalgar*.
Moderate : *Stirling Castle*, *Sir Chas. Napier*, *Latest of All*, *Auguste Nicaise*, *Elton Pine*, *Keen's Seedling*, *Queen of Denmark*, *British Queen*.
Poor : *Noble*, *Waterloo*, *Dr. Hogg*, *President Loubet*, *Scarlet Queen*, *La Grosse Sucree*, *Louis Gauthier*, *St. Joseph*.

A considerable number of additional varieties are also grown ; but their names are not included in the above lists, since it is still uncertain how they should be classified. Regard has been paid,

in compiling these tables, not only to the cropping qualities of the varieties and the character of the fruit, but also to the habits of growth and promise of the plants in those cases where they have not yet reached maturity. Those varieties, whose names are given in italics, have done particularly well, or have been absolute failures, as the case may be.

Strawberry Experiments.—A series of experiments on the cropping qualities of strawberry plants has been completed. It has been shown that the plants produced from the first runners on the off-shoots of the parent plant, *i.e.*, those nearest the parent plant, tend to be decidedly more fruitful than those derived from the "second" runners, *i.e.*, those second on the off-shoots from the parent plant. Five varieties were tested in this manner, and, with one exception, where the yields were practically equal, the results were decidedly in favour of the "first" runners. Taking the three year period over which the experiments extended, the total weights for the five varieties taken together showed a margin of 20 per cent. on the side of the "firsts."

A large number of seedling plants raised from crosses are being grown in connection with investigations on the application of Mendelian principles to the breeding of market fruits.

Pruning Experiments.—Various series of pruning experiments have been carried on with all fruits grown in bush form at the Institute. From their nature they require to be carried on for a number of years before the results can be fairly estimated; and the following record of the results must be taken as simply a statement of them as far as they have proceeded to date.

With apples and pears generally the results show that, except for very strong-growing varieties, where root-pruning is probably desirable to force a crop, and for very weak-growing varieties, where severe winter pruning may be required in the early stages to encourage good wood formation, the less the trees have been pruned thus far the better, when both growth and cropping qualities are considered. The pruning referred to has reference only to the cutting back of the extension shoots and the lateral branches, and to root-pruning. The removal of all superfluous wood is, of course, desirable in every case.

For gooseberries, pruning on what is described in previous Reports as the "light" system has given slightly better results than the "hard" system.

Red currants, pruned according to the modern basin-shaped system with open centres, have failed to give such good results as those pruned on the old plan, with branches left in the centre of the bushes.

It should be mentioned here, however, that these experiments were only started after the bushes had been planted three years, during which time all had been pruned in the latter style. Probably the cutting away of so much wood from the centres of the bushes of the former group at so late a stage has adversely affected their returns. These experiments are being repeated with younger bushes, and the results from these should be more reliable.

Spraying Trials.—Considerable attention has been given to the question of insect and fungoid pests of fruit trees and fruit. The most elaborate work has been in connection with the fungicidal action of Bordeaux Mixture. A detailed account of this work is now in the press, and it is unnecessary to refer to it further here, except to state that it is believed that considerable advance has been made in our knowledge of its mode of action, and that the essential point to observe with regard to its use is that the deposit of the insoluble copper compound should be made to cover as completely as possible every portion of the surface of the plants sprayed.

A large number of winter spray fluids, recommended by various authorities, have been tested, on the whole with disappointing results. While in nearly every case the trees have been more or less effectively freed from growths of moss and lichen, there has been a general failure to reduce seriously the number of injurious insects. The most satisfactory results, as far as insect pests are concerned, have, on the whole, been obtained with the various lime washes, such as the lime, sulphur, and salt wash and the Oregon mixture.

Very satisfactory results have been obtained with copper sulphate solution (5 per cent.), used as a fungicidal winter wash. Where apple trees were thoroughly drenched with this fluid in March, the fruit, without further spraying, showed almost complete immunity from scab the following summer, although in previous years it was badly attacked with the disease.

The two most serious pests at the Institute have undoubtedly been the Woolly Aphis (American blight), and canker, *Nectria ditissima*. No treatment in the form of spraying has had any perceptible benefit in combating the former. The only method of dealing with it at all successfully has been the application of a suitable liquid to the affected area by hand with a brush. Several of the usual substances have been tried with adequate results; but a mixture of colza oil and water in equal parts, with sufficient soft soap added to make an emulsion, has proved to be perhaps more useful than any other.

Canker has been very widespread, but so long as the Woolly Aphis is kept in check the number of outbreaks is lessened. A

general heavy dressing of lime to the fruit plantations, nurseries, and orchards, given in 1907, proved very beneficial in checking its advance. The most efficient method of dealing with the affected wood has been to cut away the diseased portion and cover the diseased cut with an antiseptic or air-excluding dressing, such as Stockholm tar or painter's knotting. The best dressing thus far tried is undoubtedly lysol, which is used mixed with water in the proportions of one part of the former to four parts of the latter. This mixture is simply painted on the cut surface with a small brush; and the growth of new healthy tissue, which follows, is remarkably good in nearly every instance.

EDUCATIONAL, ADVISORY, AND OTHER WORK.

Owing to the many-sided character of its work and the limited expert staff available the Institute has not been in a position to pay more than a limited amount of attention to the educational side. With so extensive an area as the six contributing counties in the West of England to consider it has been necessary to adopt the policy of centralising such work and of making it as general as possible rather than that of dealing with demands of a more local character. The following outline indicates the manner in which an effort to make the Institute as generally useful as possible has been made.

The Institute has always been open to visitors interested in cider-making and fruit culture, not only to inspect the work which has been in progress, but also to consult the staff for information and advice. Over 2,000 visitors have taken advantage of this privilege since the opening of the Institute. Each of the contributing counties has from time to time organised special parties to visit the Institute. In addition, a large number of enquiries have been dealt with by correspondence in cases where personal visits could not be arranged.

Each season an annual Tasting Day has been arranged, open to all members and associates of the Institute and to residents in the contributing counties interested in cider-making and fruit culture. On such occasions the ciders made in connection with the experimental work of the current season have been available for sampling; and attempts to render the occasion as educational as possible to visitors have been made by demonstrations and other means. The attendance has been an increasing one each year.

Several conferences have also been arranged, general invitations to which have been issued to interesting residents in the contributing counties. At these papers of educational value have been read and instructive discussions have followed.

Once or twice annually public demonstrations of various processes connected with fruit culture, such as tree planting, pruning, grafting, and spraying, have been organised. These have proved of particular interest to fruit growers.

Each year educational exhibits illustrating the work of the Institute have been sent to the County Agricultural Societies' Shows in each contributing county as well as to those of the Bath and West and, usually, the Royal Agricultural Societies. Similar exhibits have also been sent to exhibitions of agricultural produce, organised by the County Agricultural Education Departments in certain of the contributing counties, and to a number of other shows and exhibitions attended by fruit growers and cider makers.

Annual Reports of the experimental work have been issued and distributed in each contributing county: and a series of leaflets dealing with special points concerned with fruit culture and cider-making has also been circulated.

Individual tuition to pupils taking courses of instruction in cider making and fruit culture has been arranged. Students are received on the following terms:

For a course of instruction in the Practice and Science of Cider-making (including practical work in the cider-house and laboratory work) 4 guineas for one month's course, and 10 guineas for a three months' course.

For instruction in Practical Fruit Culture (and Cider-making, if desired,) working pupils from subscribing counties are received for a period of not less than one year. The pupils receive a wage of 7s. 6d. per week.

A special course on Fruit Culture and Cider-making was arranged for two seasons conjointly with University College, Bristol; but owing to the establishment of Bristol University in 1909 this course is temporarily suspended pending the reconstruction of the Agricultural Department at the latter institution. Subscribing counties were entitled to nominate annually one student to take this course free of fees.

The Institute has taken an active part in several matters touching the welfare of the cider industry. Special reference may be made to the following.

By arrangement with a number of Local Authorities a systematic examination was made to determine the purity of ciders exposed for sale in different localities. As a result important information as to the extent of adulteration commonly found was furnished, and

in a number of instances beverages sold as cider and containing no apple juice whatever were met with. A conference of cider makers was called to discuss the matter and to consider the advisability of endeavouring to get a legal standard for cider established, and a deputation to lay the matter before the President of the Board of Agriculture was organised. The Board expressed the desire to assist, as far as the present state of the law permitted, and have since taken steps to put a stop to the sale under the name of cider of any liquor not containing apple juice.

The railway rates for the carriage of cider fruit have given rise to considerable dissatisfaction. Consequently the Institute, in conjunction with the National Association of Cidermakers, opened negotiations with the railway companies concerned, and to some extent have succeeded in obtaining more favourable terms.

The proposal in the Budget of 1909 to impose a duty upon cider met with so much opposition among cidermakers that the Institute took an active part in the matter, and brought to the notice of the Government the serious effect the proposed duties would have in checking the development of the industry. The proposal was eventually withdrawn.

Considerable attention has been given by the Institute to the question of the future of the cider industry; and it is strongly felt that unless more care is given to the cider orchards it is seriously threatened. In two directions efforts to improve the existing state of affairs have been made: firstly, by the establishment of demonstration orchards in a number of districts in each of the subscribing counties to serve as a means of arousing local interest to illustrate the best methods of management, and to introduce varieties of superior quality,—fifty such orchards have now been established with trees raised in the nurseries of the Institute,—and, secondly, by the direction of attention to the necessity of planting new orchards to take the place of those which are becoming exhausted. Information is being collected with the object of publishing a pamphlet showing the financial side of the question as an appeal to landowners and growers and an illustration of the value of vintage orchards as an investment.

It is desired to take this opportunity of urging all interested in fruit culture and cider-making to become Members or Associates of the Institute. At the end of the second year of its establishment the number of Members and Associates totalled 53; and it has steadily increased until it has now been practically trebled. The support which may be expected in the way of grants from public bodies depends very largely upon that given by indi-

viduals whom the work directly concerns; and it is therefore important that the membership should be strong and thoroughly representative. Members' subscriptions are one guinea per annum, for which they receive all literature published by the Institute, and can have either six varieties of apples or pears, or six kinds of cider or perry analysed gratis each year. They are also able to purchase cider and perry trees raised at the Institute to the number of 100 per annum at the rate of 2s. per tree, (to non-members the price is 2s. 6d. per tree) as far as the supply permits. Grafts and buds of apples and pears are also available. Associates' subscriptions are 5s. per annum. They have the same privileges, with the exceptions that they are unable to vote at General Meetings, and that the number of trees which they can obtain at discount rates is 25 per annum. Members and Associates can visit the Institute at any time to inspect the work and to consult the staff upon all matters concerned with fruit culture and cider-making.
